Oak Harvesting Guidelines to Reduce the Risk of Introduction and Spread of Oak Wilt

Map Creation Date: Jan. 1, 2016 **Map good through: Dec. 31, 2016**

For the on-line interactive guide, visit dnr.wi.gov Keyword: oak wilt

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Chapter 1
Introduction

Oak is a very important component of Wisconsin's forests ecologically and economically[1]. Oak wilt, caused by the fungus, *Ceratocystis fagacearum* is considered one of the most serious diseases of oaks (*Quercus* spp.) in the United States, particularly in the upper Midwest and Texas. Oak wilt is commonly found in the southern two-thirds of Wisconsin. The disease kills many oaks each year by blocking the tree's water and nutrient-conducting systems.

Long-distance spread of oak wilt into a previously disease-free stand occurs through insects that carry oak wilt spores. The sap feeding beetles, which are very small, are attracted to oak wilt fungal mats found beneath the cracked bark of trees that died of oak wilt the previous year. The beetles then transport oak wilt spores to a fresh wound on an oak tree or a freshly cut oak stump. The greatest risk of oak wilt transmission occurs in the spring, when a high number of oak wilt-carrying beetles are present.

Once the disease is established in a stand, the fungus can spread from an infected tree to healthy trees through an interconnected root system (root graft), creating a pocket of dead oak trees that can expand slowly over years, if no management steps are taken. Once oak wilt establishes itself in an area, control of the disease is difficult and costly. Preventing disease introduction is the best approach.

These stand-level Oak Harvesting Guidelines provide seasonal oak harvesting guidelines in order to reduce the risk of oak wilt transmission, followed by various Exceptions and Modifications that can be applied to specific situations. Also included is the stand-level oak wilt risk assessment information (Appendix A) that can be used as a tool to further assess the stand, especially when Exceptions or Modifications are considered. The Guidelines are intended to provide forestry professionals and landowners with information about the relationship between the risk of oak wilt transmission and the timing of any activities that may wound oaks or leave oak stumps. The Guidelines should be considered part of sustainable oak management within the context of generally accepted forestry practices, while protecting soil, water and biodiversity.

The Guidelines do not address landscape-level management issues or the management of actively-expanding oak wilt pockets. However, when an oak harvest is planned during the restricted period, consideration of the potential impact of oak wilt on adjacent stands is encouraged. In addition, proper handling of oak wilt infected wood will reduce the risk of long-distance overland introduction of the disease. Links to information about the management of active oak wilt stands is available in Appendix B. Interested individuals are encouraged to discuss stand-specific options with their regional DNR Forest Health Specialist or forester.

The Guidelines are not prescriptions for managing oaks or regenerating oaks. The silvicultural prescription should come from other sources such as the Wisconsin DNR Silviculture Handbook. These Guidelines are meant to be used in conjunction with these other sources.

[1] For more information about oak resources in Wisconsin, please refer to Appendix B.

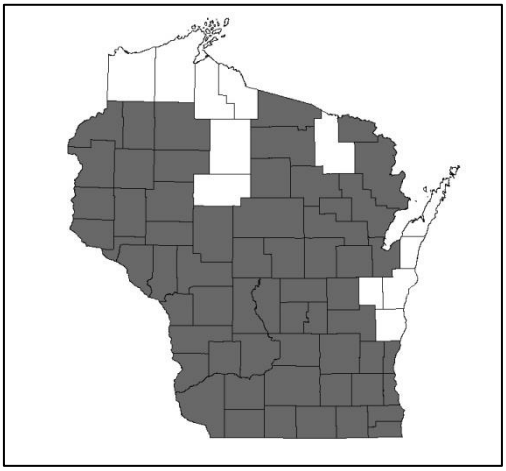
Using the Guidelines

The Oak Harvesting Guidelines, pertinent to oak wilt, are used for forest management activities on DNR lands, County Forests and lands entered in Wisconsin forest tax law programs. The guidelines reduce the risk and spread of oak wilt and support the sustainable management of forests in Wisconsin. On public lands, foresters use the guidelines when setting up timber sales to ensure that sustainable forestry is practiced and consistent with the management plan for the property. On private lands, landowners participating in the Managed Forest Law and Forest Crop Law programs agree to practice sound forestry on their woodlands, which includes using the Oak Harvesting Guidelines, when conducting forest management activities.

How to use the Guidelines

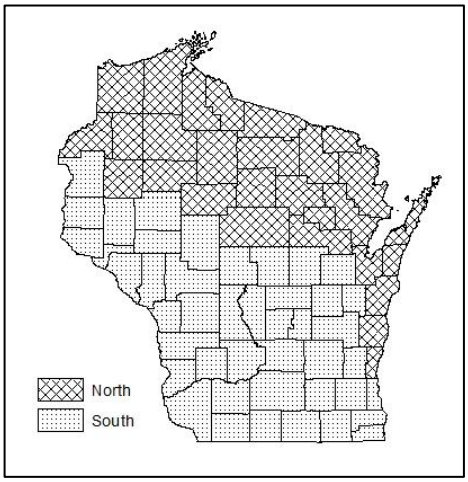
The Guidelines have three options, based on the location of the stand that you are managing:

- If your stand is in a county that does not have oak wilt AND is NOT within 6 miles of a county with oak wilt, read Chapter 2.
- If your stand is in a county that has oak wilt OR is within 6 miles of a county with oak wilt AND oak wilt is NOT in your stand, read Chapter 3.
- If oak wilt is present in the stand, read Chapter 4.



Map of known counties with oak wilt.
Map Creation Date: January 1, 2016
Map is good through: December 31, 2016

The map at right shows the known county-level distribution of oak wilt in Wisconsin. This map should be considered at the time of timber sale establishment. The county-level map in the Guidelines is updated annually on January 1st and good through the end of the year (December 31). Even if oak wilt is confirmed in a county for the first time during the year, the Guidelines allow users to continue to refer to the map in the Guidelines until the "good through" date expires. The Guidelines give users a choice of following the map in the Guidelines until the end of the year or using the up-to-date on-line map. The most current map is available on-line at dnr.wi.gov (Keyword: oak wilt).



In order to find the harvesting-restricted period due to oak wilt in your county, determine whether your county is located in the area designated as North or South as shown in the map at right. The state is divided into two areas based on climate information. Harvesting-restricted periods were identified using recent research data regarding the emergence and flight patterns of the insects that spread oak wilt spores. The harvesting-restricted periods are between April 15th through July 15th in the North zone and April 1st and July 15th in the South zone.

Besides a general recommendation about whether the oak harvesting-restricted period should apply, the Guidelines state specific situations as Exceptions and Modifications. It is important to read the entire document before making a management decision about when harvesting should be conducted in a stand. For more information, read Chapter 5: Guideline Rationale and Implementation Notes. Relevant section(s) are indicated after the symbol "☞"

Differences between Exceptions and Modifications–documentation requirements

If any of the Exceptions or Modifications apply to your stand, you may not need to implement the seasonal harvesting restriction due to oak wilt. However, consider that seasonal harvesting restrictions may apply for other sustainable management purposes, such as for soil conservation, endangered/threatened species considerations, or the protection of advance regeneration. Also, consider the potential impact to adjacent stands due to oak wilt if you choose to harvest during the harvesting-restricted period.

Please note that there are differences between Exceptions and Modifications. Exceptions are considered relatively common and are straightforward to apply. No detailed justification is needed to apply the Exceptions. However, a short explanation of which Exception was used should be included in the timber sale documentation. Modifications are considered to be stand-specific, and consultation with your regional DNR Forest Health Specialist or forester is recommended to assess applicability.

Justification for Modifications needs to be documented and included into the normal approval process for harvesting. For public lands, justification for using a Modification should be included in Form 2460-001 (Timber Sale Notice and Cutting Report). For Managed Forest Law and Forest Crop Law lands, it should be included in Form 2450-032 (Cutting Notice and Report of Wood Product). If the Exception/Modification requires a change in these forms, justifications should be added accordingly.

Stand-level oak wilt risk assessment

Risk levels specific to your stand are described in Appendix A. This information should be used as a tool to further assess the stand and oak wilt risks, especially when the use of Exceptions or Modifications is being considered. Risk of oak wilt introduction into a stand and risk of below-ground spread within a stand once the disease is introduced are rated separately because the factors involved in the two risks are different.

- Two factors were considered in determining the risk of introduction of oak wilt into a stand; (1) time of year during which harvesting activities occur, and (2) proximity of existing oak wilt stands.
- Three factors were considered in determining the risk of below-ground spread of the disease; (1) pre-harvest basal area of oak, (2) general topographic relief, and (3) soil type.

Risk ratings range from very low to very high for each risk category, and a combined risk level is also shown to help assess the overall impact of the disease on a particular stand.

To obtain stand-specific risks, follow the steps below:

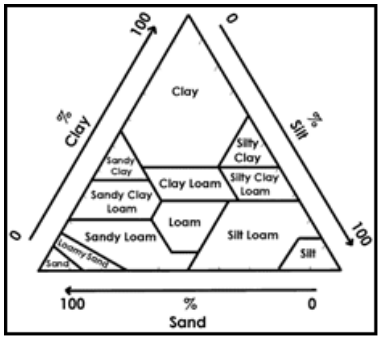
1. Choose the location of the stand
   - Your stand is in a county that has oak wilt OR is within 6 miles of a county with oak wilt AND oak wilt is NOT in your stand
   - Your stand is in a county that does not have oak wilt AND is NOT within 6 miles of a county with oak wilt
   - Oak wilt is present in your stand

2. Determine the pre-harvest basal area of oak

- Oak basal area is less than 15 square feet per acre
- Oak basal area is 15-35 square feet per acre
- Oak basal area is more than 35 square feet per acre

3. Choose the topography description that best describes the stand
   - Flat to rolling includes terrain that has 0-12% slope
   - Hills and valleys are characterized by slopes >12%

4. Choose the soil type
   - Light (sandy, loamy sand, sandy loam, sandy clay loam, loam)
   - Heavy (sandy clay, clay, clay loam, silt, silt loam, silty clay loam, clay loam)



Soil composition triangle (Source: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p

Use the tables in Appendix A to obtain the risks for your stand

Oak cutting and pruning recommendations in urban areas

This guide was developed for forest settings. For WI DNR's recommendations in urban areas, please visit dnr.wi.gov (Keyword: oak wilt). Check with your municipality to find out if they have their own oak wilt ordinances that you should follow as well. For oak pruning guidelines in utility setting, please visit the Public Service Commission of Wisconsin website at http://psc.wi.gov/.

Handling of oak wilt infected wood

Currently, there is no state regulation on the movement of oak wilt infected wood, but transportation of firewood and logs with bark has a potential to spread oak wilt. This is one way that oak wilt can be spread long distances to areas of the state that do not have oak wilt. Trees that wilt during the summer and early fall due to oak wilt often produce mats of the oak wilt fungus under the bark the following spring and early summer. Mat formation is very common on red oak species. However, it is uncommon on bur oaks (*Q. macrocarpa*), and seldom on white oaks (*Q. alba*), thus the risk of transporting the pathogen through infected white oak species is much less. If you move oak firewood or logs that were recently killed by oak wilt, utilizing the material before April 1st of the year following mortality will minimize the risk of the fungus spreading overland via insects. Infected firewood can be covered with 4 mil plastic tarp down to the ground and weighted down so beetles won't enter the pile, and stored in the sun over the summer for use the following winter. Wood is no longer infectious once the bark is loose and/or has fallen off. For more information about handling of oak wilt infected wood, please refer to resources listed in Appendix B.

Chapter 2
If your stand is in a county that does not have oak wilt AND is NOT within 6 miles of a county with oak wilt

Seasonal Oak Harvesting Guideline
Harvesting can be considered any time of the year because there is a large distance between your stand and known locations of oak wilt. However, it is possible that oak wilt is present in areas where the disease has not been confirmed. If you choose to harvest during the harvesting-restricted period due to oak wilt (North 4/15-7/15; South 4/1-7/15), consider the potential impact to adjacent stands.

Exceptions (☞Chapter 1)

None

Modifications (☞Chapter 1)

None

Chapter 3
If your stand is in a county that has oak wilt OR is within 6 miles of a county with oak wilt AND oak wilt is NOT in your stand

Seasonal Oak Harvesting Guideline

Harvesting is recommended only during the non-restricted period due to oak wilt.

Any activities that may wound oaks should only be considered during the harvesting-restricted period under certain conditions listed below as Exceptions or Modifications. It is possible that oak wilt is present in a stand where the disease has not been confirmed.

If you choose to conduct any activities that may wound oaks during the harvesting-restricted period due to oak wilt, consider the potential impact to adjacent stands.

Harvesting-restricted period due to oak wilt
North: April 15 to July 15
South: April 1 to July 15

Exceptions (☞Chapter 1)

1. **The stand is being converted to a non-oak type** (☞ Chapter 5.2)
2. **Oak is not considered to be an important component of the stand's future**
3. **Basal area of oak is less than 15 square feet per acre** (☞ Chapter 5.3 and 5.9)

3A: If basal area of oak is in the range of 16 to 20 square feet per acre, an exception may also apply; however evaluate the stand conditions carefully to minimize the negative effects of harvesting during the harvesting-restricted period due to oak wilt.
Note: In a stand with low oak basal area, if oaks are harvested during the harvesting-restricted period, a landowner may consider applying wound dressing or herbicides to oak stumps immediately, as a precaution against stump infection. This additional treatment can also be applied to perimeter stumps to reduce the risk of introduction of the disease to neighboring stands.

4. **The stand where white oak (*Q. alba*) is the only oak species present** (☞Chapter 5.6)
5. **Overstory removal with one of the following conditions;**

- Adequate regeneration is attained by seed-origin seedlings of any oak species and any type of regeneration of non-oak species. This presumes that full stocking is likely without dependence on oak stump sprouts. (☞ Chapter 5.7)
- Adequate regeneration is attained by seed-origin seedlings of any oak species, supplemented by coppice regeneration of *Q. alba* (not other oak species) and any type of regeneration of non-oak species. This presumes that full stocking is not attained solely by seed-origin oak seedlings, but that full stocking is likely by a combination of seed-origin seedlings of any oak species, coppice regeneration of *Q. alba,* and any type of regeneration of non-oak species. (☞ Chapter 5.4)
  Note: Reserve trees of oak species can be left in a stand at the time of overstory removal depending on the landowner's objectives. (☞Chapter 5.5)

6. **The stand is in a county where oak wilt is present but uncommon (primarily some areas in the northern third of Wisconsin)**
   If your stand is located in an area where oak wilt is uncommon or not "generally infested" (check with the current oak wilt township-level distribution map on-line at dnr.wi.gov (Keyword: oak wilt) or contact your regional DNR Forest Health Specialist for their recommendation based on their local knowledge), and if there is no oak wilt within 6 miles of your stand, the risk of introduction of the disease will be reduced and seasonal harvesting restrictions may not be necessary. In general, oak wilt is so common in the southern two-thirds of Wisconsin that it would be unusual to have an area that is free of oak wilt for 6 miles in all directions (i.e. counties listed as "generally infested" in the township-level map). Note: the online township-level map is based on best available data, but it may be incomplete. It is possible that oak wilt is present in the areas where the disease has not been documented.

Modifications (☞Chapter 1)

1. **When basal area of oak is slightly more than 20 square feet per acre due to scattered, large-diameter oaks** (☞Chapter 5.3 and 5.9)
   A few large trees (i.e. larger than 24 inches in dbh) may be raising basal area higher than 20 square feet per acre, but these trees are far apart from each other (~100 feet or more, or refer to the root graft table in Appendix B), thus infection of a stump would not result in introduction of disease into a connected root system. In these cases, seasonal harvesting restriction on the stand may not be necessary. Contact a forester and/or your regional DNR Forest Health Specialist for further discussions.
   Note: In a stand with low oak basal area, if oaks are harvested during the harvesting-restricted period, a landowner may consider applying wound dressing or herbicides to oak stumps immediately, as a precaution against stump infection. This additional treatment can be applied to perimeter stumps to reduce the risk of introduction of the disease to neighboring stands.

2. **Salvage harvesting**
   If a stand is exposed to high potential loss on residual trees due to a natural disaster or multiple forest health issues, and the stand needs to be harvested quickly to capture wood value, harvesting during the harvesting-restricted period due to oak wilt may be economically justified. Natural disasters include wind events, fire, flooding, insect and disease activity and weather extremes. Consult your regional DNR Forest Health Specialist or forester. If you choose to harvest during the harvesting-restricted period, consider the potential impact of introducing oak wilt to adjacent stands.

3. **Unusual weather patterns in early spring** (☞Chapter 5.1)
   In some years, Wisconsin experiences unusually warm temperatures in March, and may be at high risk for oak wilt transmission during this time. The rule of thumb is that "temperatures above 60 degrees for 7 consecutive days" could put a stand at high risk in March. In other years, there may be low temperatures in March to early April, and harvesting may be justified after April 1st in the South or after April 15th in the North. When experiencing an unusually cold spring, the extension of harvesting into April will be up to the comfort level of the landowner/property manager based on the weather conditions and relative importance of completing the harvest. When harvesting deadlines are extended, it

is important to be aware that the stumps and wounds are susceptible for up to 72 hours after cutting. Consult your regional DNR Forest Health Specialist for their recommendation in the area where your stand is located.

Chapter 4
If oak wilt is present in your stand

Seasonal Oak Harvesting Guideline

Harvesting is recommended only during the non-restricted period due to oak wilt.
Any activities that may wound oaks should only be considered during the harvesting-restricted period under certain conditions listed below as Exceptions or Modifications.

If you choose to conduct any activities that may wound oaks during the harvesting-restricted period due to oak wilt, consider the impact to adjacent stands.

Follow recommendations on handling infected wood (☞Chapter 1).

Harvesting-restricted period due to oak wilt
North: April 15 to July 15
South: April 1 to July 15

Exceptions (☞Chapter 1)

1. **The stand is being converted to a non-oak type** (☞Chapter 5.2)
2. **Oak is not considered to be an important component of the stand's future**
3. **Basal area of oaks is less than 15 square feet per acre** (☞Chapter 5.3 and 5.9)
   Note: In a stand with low oak basal area, if oaks are harvested during the harvesting-restricted period, a landowner may consider applying wound dressing or herbicides to oak stumps immediately, as a precaution against stump infection. This additional treatment can also be applied to perimeter stumps to reduce the risk of introduction of the disease to neighboring stands.
4. **The stand where white oak (*Q. alba*) is the only oak species present** (☞Chapter 5.6)
5. **Overstory removal with adequate seed-origin seedling regeneration** (☞Chapter 5.7)
   This presumes that full stocking is attained by seed-origin oak seedlings and any type of regeneration of non-oak species.
   Note: Reserve trees can be left in a stand at the time of overstory removal depending on the landowner's objectives (☞Chapter 5.5)
6. **Oak wilt is widespread** (i.e. multiple dispersed oak wilt pockets, greater than one pocket per 5 acres) **in a stand of black and/or northern pin oak** (i.e. *Q. velutina*/*Q. ellipsoidalis* comprises 50% or more of the stand basal area) on sandy soils with flat terrain **while conducting a regeneration harvest** (☞Chapter 5.8)
   Note: Follow the recommendation for handling of infected wood (☞Chapter 1)

Modifications (☞Chapter 1)

1. **When basal area of oaks is slightly more than 15 square feet per acre due to scattered, large-diameter oaks** (☞Chapter 5.3)
   A few large trees (i.e. larger than 24 inches in dbh) may be raising basal area higher than 15 square feet per acre, but these trees are far apart from each other (~100 feet or more, or refer to the root graft table in Appendix B), thus infection of a stump would not result in

introduction of disease into a connected root system. In these cases, seasonal restriction of such a stand may not be necessary. Contact a forester and/or your regional DNR Forest Health Specialist for further discussions. The use of wound dressing may be appropriate in some situations. In a stand with low oak basal area, if oaks are harvested during the harvesting-restricted period, a landowner may consider applying wound dressing or herbicides to oak stumps immediately, as a precaution against stumps becoming infected. This additional treatment can be applied to perimeter trees to reduce the risk of introduction of the disease to neighboring stands.

2. **Adequate regeneration is attained by seed-origin seedlings of any oak species, supplemented by coppice regeneration of *Q. alba* (not other oak species) and any type of regeneration of non-oak species** (☞Chapter 5.4)
   This presumes that full stocking is not attained solely by seed-origin oak seedlings, but full stocking is likely by a combination of seed-origin seedlings of any oak species, coppice regeneration of *Q. alba*, and any type of regeneration of non-oak species. The overstory stand may be mixed with various oak species both from the red oak group and white oak group, or with only oak species in the white oak group.

3. **Salvage harvesting**
   If a stand is exposed to high potential loss on residual trees due to a natural disaster or multiple forest health issues, and the stand needs to be harvested quickly to capture wood value, harvesting during the harvesting-restricted period due to oak wilt may be economically justified. Natural disasters include wind events, fire, flooding, insect and disease activity and weather extremes. Consult a regional DNR Forest Health Specialist or forester. If you choose to harvest during the harvesting-restricted period, consider the impact of introducing oak wilt to adjacent stands. Treatment of oak stumps along the perimeter with wound dressing or herbicide may reduce this risk.

4. **Unusual weather patterns in early spring** (☞Chapter 5.1)
   In some years, Wisconsin experiences unusually warm temperatures in March, and may be at high risk for oak wilt transmission during this time. The rule of thumb is that "temperatures above 60 degrees for 7 consecutive days" could put a stand at high risk in March. In other years, there may be low temperatures in March to early April, and harvesting may be justified after April 1 in the South or after April 15 in the North. When experiencing an unusually cold spring, the extension of harvesting into April will be up to the comfort level of the landowner/property manager based on the weather conditions and relative importance of completing the harvest. When harvesting deadlines are extended, it is important to be aware that the stumps are susceptible for up to 72 hours after cutting. Consult a regional DNR Forest Health Specialist for their recommendation in the area where your stand is located.

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Chapter 5: Guideline Rationale and Implementation Notes

5.1 Emergence/flight patterns of insects that carry oak wilt spores (vectors)

Our understanding of vector emergence and flight patterns in the upper Midwest has increased significantly during the last two decades. The abundance of the two major vectors of oak wilt (Juzwik et al., 2004) – *Colopterus truncatus* and *Carpophilus sayi* – was investigated in Minnesota in 2002 and 2003 (Ambourn et. al., 2005). Abundance and contamination rate of *C. truncatus* with the oak wilt fungal spores peaked in April and May. Abundance of *C. sayi* peaked in October, but the pathogen was most commonly isolated from beetles collected during May and June. As a rule of thumb, "temperatures above 60 degrees for 7 consecutive days" is considered to be warm enough for the emergence of *C. truncatus* (J. Juzwik, USDA Forest Service, personal communication). A degree day modeling research project to predict the emergence of these major vectors was initiated in 2015 by the University of Wisconsin-Madison, Department of Entomology. It is possible that the results of the study will be used to modify the Guidelines in the future.

5.2 Converting to non-oak species

Although oak wilt is a serious disease of oak, it does not impact other species that are native to Wisconsin (Himelick and Fox, 1961). The pathogen will not persist in the stand once suitable host materials do not exist.

5.3 Impact of oak wilt based on oak basal area

When the existing basal area of oak is high, harvesting during the harvesting-restricted period is not recommended for the following reasons;

1. Even if all oak stumps were immediately treated with wound dressing, residual oak trees would likely be injured during harvesting activities, and these wounds would provide entry points for the oak wilt fungus.
2. If a residual oak becomes infected, the oak wilt fungus could spread from the infected trees to nearby residual trees through root grafts.
3. If the majority of oaks are infected and killed by oak wilt, the stand will no longer be fully stocked and able to meet management objectives.

Simulation models developed for the Midwestern states (Menges and Loucks, 1984), indicated that both average pocket size and percent mortality from root graft transmission increased consistently with increasing proportions from species in the red oak group. Percent mortality by root graft transmission jumped from 10% to 20% when the percentage of the red oak group increased from 10% to 20%. Once the percentage of the red oak group was 30%, root graft mortality reached 30%. Root graft mortality increased to 40% when the red oak group was more than 50% of the stand.

If a stand is fully stocked with a low oak component, the impact from underground spread is low, and seasonal harvesting restrictions may not be necessary. The stand would likely remain fully stocked even if all the oaks were to die. An oak basal area of 15 square feet per acre was adopted as a practical figure to indicate that 20% of trees within a stand are oak trees. If oak comprises less than 20% of a stand, the stand is likely to be fully stocked even if all oaks were to die.

A few very large oak trees (e.g. more than 24 inches dbh) may raise oak basal area without increasing the risk of below-ground oak wilt spread when the trees are far apart from each other. In order to accommodate such situations, when oak wilt is not present in the stand (Chapter 3), the

use of an Exception is offered if basal area of oaks is in the range of 16 to 20 square feet per acre with a careful evaluation of the stand conditions to minimize the negative effects of harvesting during the harvesting-restricted period due to oak wilt. A similar flexibility is provided under the Modifications section when oak basal area is higher than 20 square feet per acre. Contact a forester and/or your regional DNR Forest Health Specialist for further discussions to decide if a Modification will apply when oak basal area is higher than 20 square feet per acre.

When oak wilt is present in the stand (Chapter 4) and basal area is slightly more than 15 square feet per acre, the use of modification may be considered if there are a few large trees (e.g. more than 24 inches dbh) raising basal area. Contact a forester and/or your regional Forest Health Specialist for further discussions to decide if a Modification will apply when oak basal area is slightly higher than 15 square feet per acre. Note that in a stand where oak wilt is present, when oak basal area is slightly higher than 15 square feet per acre, you will need to use a Modification whereas in a stand where oak wilt is not present, when oak basal area is 16-20 square feet per acre, you could use an Exception. This difference is due to the higher risk of root graft transmission and additional overland infection when oak wilt is present in a stand.

In the Stand-level Oak Wilt Risk Assessment (Appendix A), an oak basal area of 35 square feet per acre was adopted as a practical figure to indicate a high impact due to oak wilt through below-ground spread. This basal area indicates that approximately 30% of trees in the stand are oak trees.

5.4 Adequate regeneration is attained by seed-origin seedlings of any oak species, supplemented by coppice regeneration of *Q. alba*

In general, members of the red oak group (e.g. *Q. rubra, Q. velutina, Q. ellipsoidalis*) are highly susceptible compared to the oaks in the white oak group (Juzwik et. al., 2011). Among the white oak group, white oak (*Q. alba*) is considered “highly resistant”. Naturally infected trees will exhibit branch dieback, but may not die from the disease for decades, if at all. Bur oak (*Q. macrocarpa*) and swamp white oaks (*Q. bicolor*) are considered “moderately resistant” to oak wilt. Bur oak may die several years after infection. Stands with mixtures from the white oak group may also contain interspecific hybrids, making it more difficult to distinguish the stand’s true susceptibility to oak wilt.

Stands with a mixture of oak species are common in Wisconsin. Generally these mixed stands have a significant oak wilt risk and should follow seasonal harvesting restrictions to prevent oak wilt transmission. Stands containing only oaks from the white oak group are at increased risk compared to stands where white oak (*Q. alba*) is the only oak present.

The regeneration goal in mixed stands is typically to regenerate both red and white oak species from seed-origin seedlings and sprouts. In this scenario oak wilt is still a risk to the residual stand and sprout-origin regeneration, and seasonal oak wilt restrictions should be applied. However, if adequate regeneration is attained by a combination of seed-origin seedlings of any oak species and coppice regeneration of *Q. alba*, the risk of oak wilt impacting regeneration is low, and seasonal harvesting restrictions may not need to be applied. Note that this flexibility is an Exception when oak wilt is not present in a stand (Chapter 3), whereas it is a Modification when oak wilt is present in a stand (Chapter 4). This difference considers the higher risk of root graft transmission and additional overland infection when the disease is already present in a stand.

5.5 Reserve trees

Reserve trees are left for purposes other than regeneration, such as wildlife habitat, and supporting ecological functions. Reserve trees are often retained through their natural lifespan, becoming snags and ultimately downed woody debris. If reserve trees in the red oak group are infected with oak wilt due to wounding during harvesting, these trees may still meet stand objectives if they die and become snags and coarse woody debris, but may allow oak wilt to spread through root grafts to nearby stump sprouts. However, root grafts of seed-origin seedlings to an infected reserve tree in the red oak group within the 5-6 year time period when the pathogen is still alive is unlikely. Thus, risk of transmission of the disease to seedling regeneration should be low.

It is recommended that white oaks (*Q. alba*) and/or other trees in the white oak group be favored as reserve trees over trees in the red oak group for several reasons 1. *Q. alba* is the least susceptible oak species native to Wisconsin; 2. Roots of *Q. alba* do not graft as commonly as trees in the red oak group, and 3. *Q. alba* rarely produces fungal mats.

Landowner objectives and risk tolerance should be taken into consideration when deciding to leave reserve trees if harvesting during harvesting-restricted period. For example, landowners may want to retain living trees for aesthetic purposes, and therefore may not tolerate the increased risk of oak wilt infection in the reserve trees. If you choose to harvest during the harvesting-restricted period due to oak wilt, consider the potential impact to adjacent stands.

5.6 Stands where white oak (*Q. alba*) is the only oak species present

Although relatively rare in Wisconsin, there are stands of pure white oak (*Q. alba*) or stands where *Q. alba* is the only oak species in the stand. Stands which have *Q. alba* as the only oak species present a lower oak wilt risk. Therefore seasonal harvesting restrictions due to oak wilt may not be necessary for intermediate thinnings or regeneration harvests. *Q. alba* is more tolerant of oak wilt infection than other oak species. The fungus does not move through the wood vessels of *Q. alba* as easily as in species within the red oak group, and *Q. alba* can live 20 years or longer with infection. In addition, *Q. alba* rarely produces fungal mats. However, *Q. alba* can be infected with oak wilt and may be killed by the disease, especially when combined with other stress causing factors, such as prolonged drought, or insect outbreaks. Forest managers and landowners should consider the additional risk associated with potential compounding stress factors that may impact the trees over the life cycle of the oak stand.

5.7 Overstory removal with adequate seed-origin seedling regeneration

Even-aged, overstory removal harvests present a low risk of oak wilt impact if there is adequate seed-origin seedling regeneration. Harvesting during the high risk period will attract oak wilt vectors to the fresh stumps and may introduce new oak wilt infection points, but root grafts of oak seedlings to an infected cut tree is unlikely, especially within the time period when the pathogen is still alive in the cut tree's root system (up to 5-6 years). Thus, risk of transmission of the disease to the seedling regeneration and subsequent underground spread between seedlings should be low and seasonal harvesting restrictions may not be necessary.

However, risk of transmission of the disease to residual oak trees at the perimeter of the overstory removal harvest and to reserve trees should be considered. When stump sprouts are present, the pathogen could survive longer in these root systems, presenting a risk to perimeter trees. A cautious approach to address this risk may be to apply herbicide to the stumps adjacent to perimeter and reserve trees. This treatment will discourage stump sprouting and kill potentially infected root systems more quickly, possibly reducing the risk of below-ground spread of the

disease to nearby trees (not scientifically proven). Use an appropriate method/product to ensure that nearby residual trees will not be damaged by herbicide application on stumps. It is important to note that oak wilt risk is still high for coppice or sprout-based regeneration. If you choose to harvest during the harvesting-restricted period, consider the potential impact of introducing oak wilt to adjacent stands.

5.8 Oak wilt is widespread in a stand of black and/or northern pin oak while conducting a regeneration cut

Seasonal harvesting restrictions due to oak wilt do not need to be applied in these stands if the stand meets all of the following:

- Is more than 50% black oak and/or northern pin oak
- Is on sandy soils with flat terrain
- Regeneration harvest is being conducted
- Has multiple dispersed oak wilt pockets (more than one per five acres)

In these stands, underground spread of the disease is highly likely, and each disease center could expand up to 5 acres in 10 years even without overland spread. Root grafts among species in the red oak group are extremely common and underground spread rates are very high on sandy soils (Gibbs and French, 1980; Blaedow and Juzwik, 2010).

If there is adequate seed-origin seedling regeneration, root grafts of these seedlings to an infected stump within the 5-6 year time period when the pathogen is still alive is unlikely. If the stand relies heavily on coppice regeneration, the stand may have a difficult time successfully regenerating. Prior to applying this Modification, it is important to verify that the mortality pockets were caused by oak wilt. A lab test may be necessary if the stand is located in an area where oak wilt is uncommon. If you choose to harvest during the harvesting-restricted period, be aware of the potential impact of introducing oak wilt to adjacent stands through root-graft transmission.

5.9 Use of wound dressing/herbicides

The use of wound dressing has been proven to be an effective method to protect a fresh cut surface from oak wilt (Camilli et. al., 2007), and may be appropriate in some situations. If oaks are harvested during the harvesting-restricted period, a landowner may consider immediate application of wound dressing or herbicides to stumps, as a precaution against stump infection. Immediate application of wound dressing to the last 3 growth rings will create a physical barrier to vectors, and will prevent stumps from being infected with oak wilt. Though not scientifically proven, herbicide application to stumps is believed to make the stump less suitable for pathogen infection. Herbicide application on a stump will also be effective at preventing sprouts, and thus promoting root death.

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Appendix A: Stand-level Oak Wilt Risk Assessment

The tables below show the stand-level risks of oak wilt. Please refer to the section "Stand-level oak wilt risk assessment" (page 4) in Chapter 1.

For the on-line interactive guide, visit dnr.wi.gov Keyword: oak wilt

I. If your stand is in a county that does not have oak wilt AND is NOT within 6 miles of a county with oak wilt

Pre-harvest basal area of oak	Terrain	Soil type	Date of harvest	Risk of introduction	Risk of impact	Combined risk
< 15 sq feet/acre	Flat/Rolling	Light	N: 4/15-7/15 S: 4/1-7/15	Moderate	Low	Low
< 15 sq feet/acre	Flat/Rolling	Light	7/16-9/30	Low	Low	Low
< 15 sq feet/acre	Flat/Rolling	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Low	Very Low
< 15 sq feet/acre	Flat/Rolling	Heavy	N: 4/15-7/15 S: 4/1-7/15	Moderate	Low	Low
< 15 sq feet/acre	Flat/Rolling	Heavy	7/16-9/30	Low	Low	Low
< 15 sq feet/acre	Flat/Rolling	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Light	N: 4/15-7/15 S: 4/1-7/15	Moderate	Low	Low
< 15 sq feet/acre	Hills/Valleys	Light	7/16-9/30	Low	Low	Low
< 15 sq feet/acre	Hills/Valleys	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Heavy	N: 4/15-7/15 S: 4/1-7/15	Moderate	Very Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Heavy	7/16-9/30	Low	Very Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Very Low	Very Low
15-35 sq feet/acre	Flat/Rolling	Light	N: 4/15-7/15 S: 4/1-7/15	Moderate	High	Moderate
15-35 sq feet/acre	Flat/Rolling	Light	7/16-9/30	Low	High	Low
15-35 sq feet/acre	Flat/Rolling	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
15-35 sq feet/acre	Flat/Rolling	Heavy	N: 4/15-7/15 S: 4/1-7/15	Moderate	Moderate	Moderate
15-35 sq feet/acre	Flat/Rolling	Heavy	7/16-9/30	Low	Moderate	Low
15-35 sq feet/acre	Flat/Rolling	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Moderate	Very Low
15-35 sq feet/acre	Hills/Valleys	Light	N: 4/15-7/15 S: 4/1-7/15	Moderate	High	Moderate
15-35 sq feet/acre	Hills/Valleys	Light	7/16-9/30	Low	High	Low
15-35 sq feet/acre	Hills/Valleys	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
15-35 sq feet/acre	Hills/Valleys	Heavy	N: 4/15-7/15 S: 4/1-7/15	Moderate	Moderate	Moderate
15-35 sq feet/acre	Hills/Valleys	Heavy	7/16-9/30	Low	Moderate	Low
15-35 sq feet/acre	Hills/Valleys	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Moderate	Very Low
>35 sq feet/acre	Flat/Rolling	Light	N: 4/15-7/15 S: 4/1-7/15	Moderate	Very High	High
>35 sq feet/acre	Flat/Rolling	Light	7/16-9/30	Low	Very High	Low
>35 sq feet/acre	Flat/Rolling	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Very High	Very Low
>35 sq feet/acre	Flat/Rolling	Heavy	N: 4/15-7/15 S: 4/1-7/15	Moderate	High	High
>35 sq feet/acre	Flat/Rolling	Heavy	7/16-9/30	Low	High	Low
>35 sq feet/acre	Flat/Rolling	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
>35 sq feet/acre	Hills/Valleys	Light	N: 4/15-7/15 S: 4/1-7/15	Moderate	High	High
>35 sq feet/acre	Hills/Valleys	Light	7/16-9/30	Low	High	Low
>35 sq feet/acre	Hills/Valleys	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
>35 sq feet/acre	Hills/Valleys	Heavy	N: 4/15-7/15 S: 4/1-7/15	Moderate	Moderate	Moderate
>35 sq feet/acre	Hills/Valleys	Heavy	7/16-9/30	Low	Moderate	Low
>35 sq feet/acre	Hills/Valleys	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Moderate	Very Low

II. If your stand is in a county that has oak wilt OR is within 6 miles of a county with oak wilt AND oak wilt is NOT in your stand

Pre-harvest basal area of oak	Terrain	Soil type	Date of harvest	Risk of introduction	Risk of impact	Combined risk
< 15 sq feet/acre	Flat/Rolling	Light	N: 4/15-7/15 S: 4/1-7/15	Very High	Low	Low
< 15 sq feet/acre	Flat/Rolling	Light	7/16-9/30	Low	Low	Low
< 15 sq feet/acre	Flat/Rolling	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Low	Very Low
< 15 sq feet/acre	Flat/Rolling	Heavy	N: 4/15-7/15 S: 4/1-7/15	Very High	Low	Low
< 15 sq feet/acre	Flat/Rolling	Heavy	7/16-9/30	Low	Low	Low
< 15 sq feet/acre	Flat/Rolling	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Light	N: 4/15-7/15 S: 4/1-7/15	Very High	Low	Low
< 15 sq feet/acre	Hills/Valleys	Light	7/16-9/30	Low	Low	Low
< 15 sq feet/acre	Hills/Valleys	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Heavy	N: 4/15-7/15 S: 4/1-7/15	Very High	Very Low	Low
< 15 sq feet/acre	Hills/Valleys	Heavy	7/16-9/30	Low	Very Low	Very Low
< 15 sq feet/acre	Hills/Valleys	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Very Low	Very Low
15-35 sq feet/acre	Flat/Rolling	Light	N: 4/15-7/15 S: 4/1-7/15	Very High	High	High
15-35 sq feet/acre	Flat/Rolling	Light	7/16-9/30	Low	Very High	Moderate
15-35 sq feet/acre	Flat/Rolling	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Very High	Very Low
15-35 sq feet/acre	Flat/Rolling	Heavy	N: 4/15-7/15 S: 4/1-7/15	Very High	Moderate	High
15-35 sq feet/acre	Flat/Rolling	Heavy	7/16-9/30	Low	Moderate	Moderate
15-35 sq feet/acre	Flat/Rolling	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Moderate	Very Low
15-35 sq feet/acre	Hills/Valleys	Light	N: 4/15-7/15 S: 4/1-7/15	Very High	High	High
15-35 sq feet/acre	Hills/Valleys	Light	7/16-9/30	Low	High	Moderate
15-35 sq feet/acre	Hills/Valleys	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
15-35 sq feet/acre	Hills/Valleys	Heavy	N: 4/15-7/15 S: 4/1-7/15	Very High	Moderate	High
15-35 sq feet/acre	Hills/Valleys	Heavy	7/16-9/30	Low	Moderate	Low
15-35 sq feet/acre	Hills/Valleys	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	Moderate	Very Low
>35 sq feet/acre	Flat/Rolling	Light	N: 4/15-7/15 S: 4/1-7/15	Very High	Very High	Very High
>35 sq feet/acre	Flat/Rolling	Light	7/16-9/30	Low	Very High	Moderate
>35 sq feet/acre	Flat/Rolling	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	Very High	Very Low
>35 sq feet/acre	Flat/Rolling	Heavy	N: 4/15-7/15 S: 4/1-7/15	Very High	High	High
>35 sq feet/acre	Flat/Rolling	Heavy	7/16-9/30	Low	High	Moderate
>35 sq feet/acre	Flat/Rolling	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
>35 sq feet/acre	Hills/Valleys	Light	N: 4/15-7/15 S: 4/1-7/15	Very High	High	High
>35 sq feet/acre	Hills/Valleys	Light	7/16-9/30	Low	High	Moderate
>35 sq feet/acre	Hills/Valleys	Light	N: 10/1-4/14 S: 10/1-3/31	Very Low	High	Very Low
>35 sq feet/acre	Hills/Valleys	Heavy	N: 4/15-7/15 S: 4/1-7/15	Very High	Moderate	High
>35 sq feet/acre	Hills/Valleys	Heavy	7/16-9/30	Low	Moderate	Low
>35 sq feet/acre	Hills/Valleys	Heavy	N: 10/1-4/14 S: 10/1-3/31	Very low	Moderate	Very Low

III. If oak wilt is present in your stand

Research has shown that the risk of introducing new infections into a stand that already has oak wilt is higher than in stands that do not have oak wilt. If oak wilt is already in the stand, it is important to consider whether or not new introductions will impact your management objectives. Consider how the presence of oak wilt affects your objectives. That will help you determine whether you are going to focus on disease management or tolerate the presence of the disease.

The risk of new oak wilt introductions is higher in already-infected stands because the dispersing nitidulid beetle vectors tend to be contaminated with the fungus more often than dispersing beetles in stands that are free of oak wilt. It is likely that the disease will continue to impact the stand if root grafts are present between oak trees. The presence of fungal mats in the stand will provide local sources of the pathogen for overland spread. The combined risk of pathogen presence and spread is believed to increase over time unless there are natural or artificial breaks in the root graft connections.

Appendix B: Resources

General information
WDNR Division of Forestry – http://dnr.wi.gov/topic/forestry.html
WDNR Foresters – http://dnr.wi.gov/topic/ForestLandowners/locator/index.asp
WDNR Forest Health Specialist - http://dnr.wi.gov/topic/foresthealth/staff.html
Managed Forest Law – http://dnr.wi.gov/topic/ForestLandowners/mfl.asp?s1=ForestTax&s2=MFL-Enrollment
Wisconsin County Forests - http://www.wisconsincountyforests.com/
Consulting Foresters – http://www.wi-consultingforesters.com/

Oak wilt general/oak wilt management/handling of oak wilt infected wood
WDNR – http://dnr.wi.gov/topic/foresthealth/oakwilt.html
UW Extension publication "Oak wilt management – What are the options?" - http://mywisconsinwoods.org/wp-content/uploads/2014/04/Oak-Wilt-Managment-Options.pdf
USDA Forest Service publication "How to Identify, Prevent, Control Oak wilt" - http://na.fs.fed.us/pubs/howtos/ht_oakwilt/identify_prevent_and_control_oak_wilt_print.pdf

Root graft table
UW Extension publication "Oak wilt management – What are the options?" - http://mywisconsinwoods.org/wp-content/uploads/2014/04/Oak-Wilt-Managment-Options.pdf

Forest/Oak resources
Wisconsin's Forest Resources - http://dnr.wi.gov/topic/ForestBusinesses/documents/WisconsinForestResources.pdf
Wisconsin's Forest Management Guidelines – http://dnr.wi.gov/topic/forestmanagement/guidelines.html

Handbooks and other guidance
Wisconsin DNR Silviculture Handbook - http://dnr.wi.gov/topic/forestmanagement/silviculture.html
Wisconsin Landowners Manual - http://wisconsinwoodlands.org/wp-content/uploads/2015/02/Wisconsin-Landowners-Manual1.pdf

Appendix C: Glossary

Coppice Regeneration Method: A silvicultural method designed to naturally regenerate a stand using vegetative reproduction.

Diameter (at) Breast Height (DBH, dbh): The diameter of the stem of a trees measured at 4.5 ft. (1.37m)from the ground (on the uphill side).

Exception: Situations that can be applied to harvest during harvesting-restricted periods due to oak wilt in these Guidelines. Exceptions are considered relatively common and are straightforward to apply. No detailed justification is needed to apply Exceptions.

Forest: 1) An ecosystem characterized by a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species composition, structure, age class, and associated processes, and commonly including meadows, streams, fish, and wildlife. 2) An organized assemblage of trees, other plants, and animals in complex association with each other and their physical environment.

Modification: Situations that can be applied to harvest during harvesting-restricted periods due to oak wilt in these Guidelines. Modifications are considered to be stand-specific, and consultation with regional DNR Forest Health specialist or forester is recommended to assess applicability.

Overstory: That portion of the trees in a forest forming the uppermost canopy layer.

Overstory Removal Regeneration Method: A silvicultural method in which the entire stand overstory is removed in one cut in order to provide release of established seedlings and saplings.

Root Graft: Union of roots from two or more closely situated trees of the same (or closely related) species.

Salvage Cutting: The removal of dead trees or trees damaged or dying as a result of injurious agents other than competition, in order to recover economic value that would otherwise be lost.

Seed-Origin Seedlings: Seedlings that grew from seeds, not from either adventitious or dormant buds from a cut tree stump.

Seedling: 1) A usually young tree smaller than a sapling. Trees smaller than one inch dbh. 2) A plant grown from seed.

Stand: 1) A contiguous group of trees sufficiently uniform in species composition structure, and age class distribution, and growing on a site of sufficiently uniform quality, to be considered a relatively homogeneous and distinguishable unit. 2) A contiguous group of similar plants

Vector: A living organism able to carry and transmit a pathogen and spread disease. In the case of oak wilt in Wisconsin, the major vectors are sap-feeding (Nitidulid) beetles, specifically *Colopterus truncatus* and *Carpophilus sayi*.

Appendix D: Contributors

The stand-level oak harvesting guidelines were originally implemented in March 2007. In 2014-2015, the guidelines were thoroughly reviewed and updated. The guidelines were developed by evaluating multiple areas, including recent research findings, experience gained in implementation of the guidelines, and economic considerations.

Oak Harvesting Guidelines were revised in 2015 with the help of the following groups:

- A stakeholder Advisory Committee – representatives from affected stakeholder groups, including industry, government, landowners, and non-profit groups.
- The Science Sub-Committee addressed science-based concerns and new research.
- The Economics and Implementation Sub-Committee addressed economic concerns and implementation practicality in the field.
- The Technical Team gathered relevant information/data, and provided recommendations that were used for discussions by the committees.
- Oak Harvesting Guidelines reviewers

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